# United States Patent [19]

**Mallosky et al.**

[11] **3,828,575**

[45] **Aug. 13, 1974**


[54] **COMPACT HEATING AND COOLING SYSTEM**


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[52] **U.S. Cl.** ..... **62/476,** 62/399, 62/485, 62/486, 62/489, 62/495, 62/496, 62/497

[51] **Int. Cl.** ..... **F25b 15/04**

[58] **Field of Search** ..... 62/476, 399, 485, 486, 62/489, 495, 496, 497; 165/161, 163



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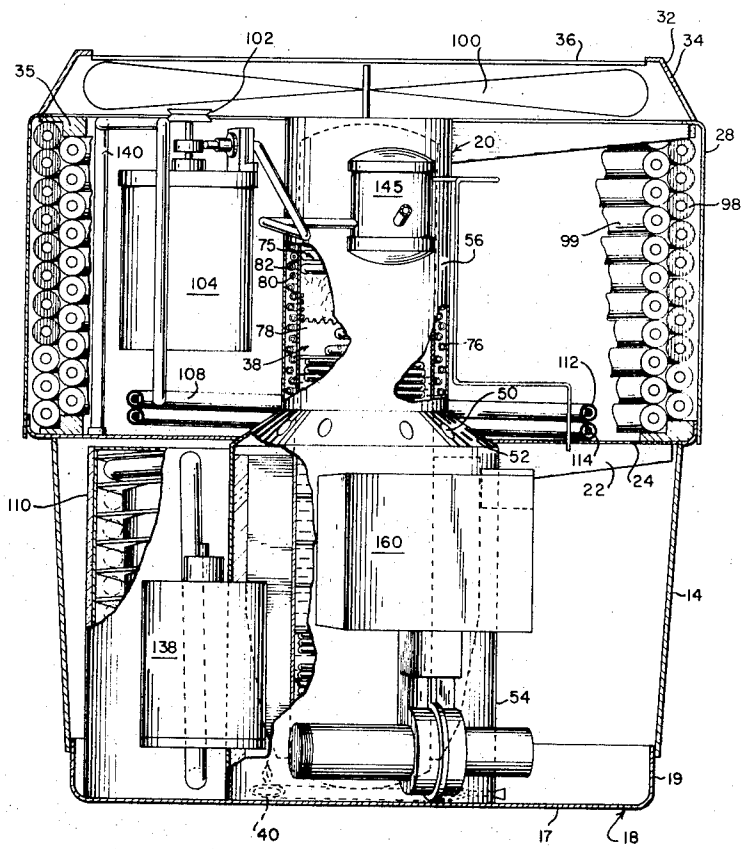
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[57] **ABSTRACT**

A compact absorption refrigeration unit has a central mounting core containing a generator about which substantially all of the components of the refrigeration system are mounted in a predetermined configuration. The generator has heat transfer fins secured to its surface which have a predetermined configuration that allows the fins and generator to absorb heat at the optimum rate at which heat can be transferred thereto without damage to the fins. The unit also includes an evaporator having a centrally positioned reservoir and a helical passageway providing a flow path for a heat exchange medium and containing a fluted helical heat exchanger tube which provides a countercurrent refrigerant, thereby to chill said heat exchange medium. In one embodiment of the invention the unit is provided with a compact boiler for use in heating the heat exchange medium, thereby permitting the unit to be selectively operated for both heating and cooling.


**17 Claims, 7 Drawing Figures**



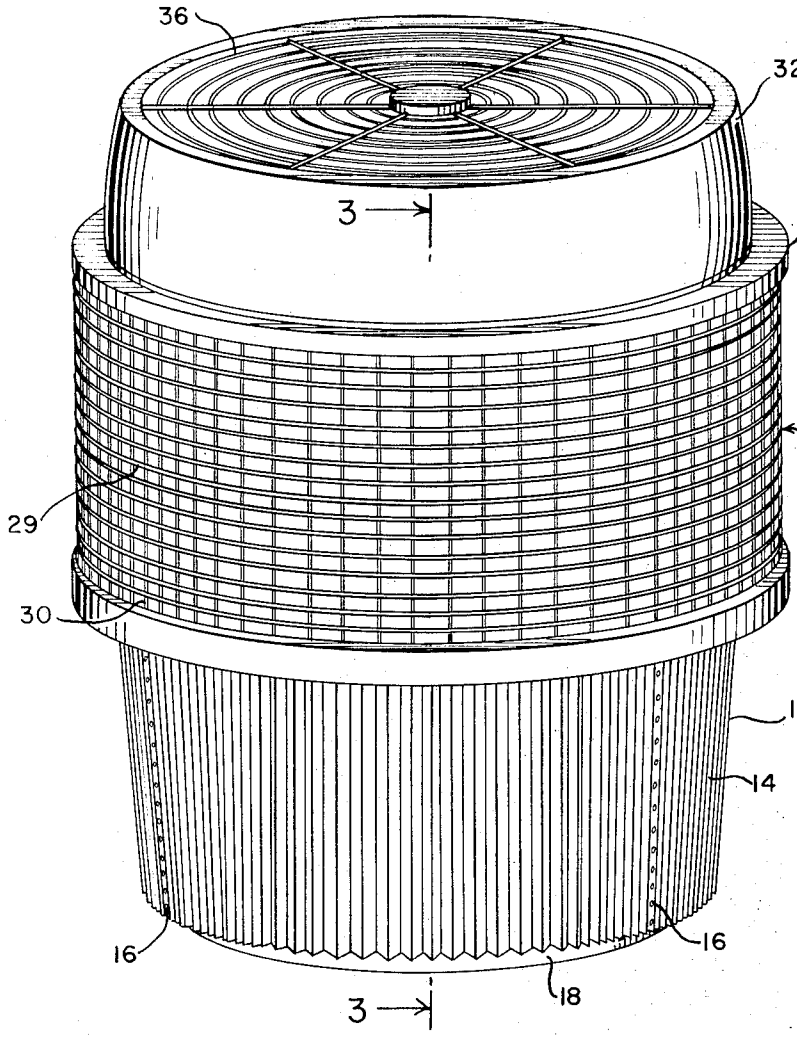

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Fig. 1

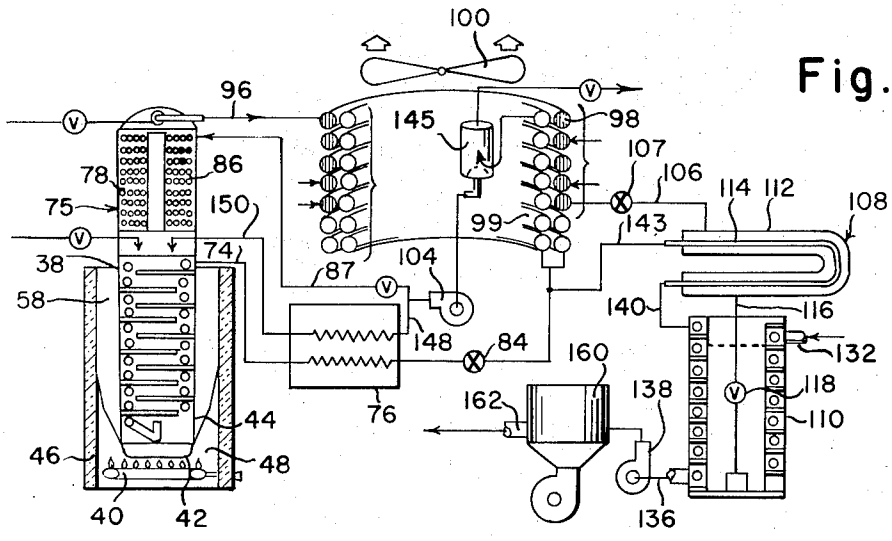

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Fig. 2

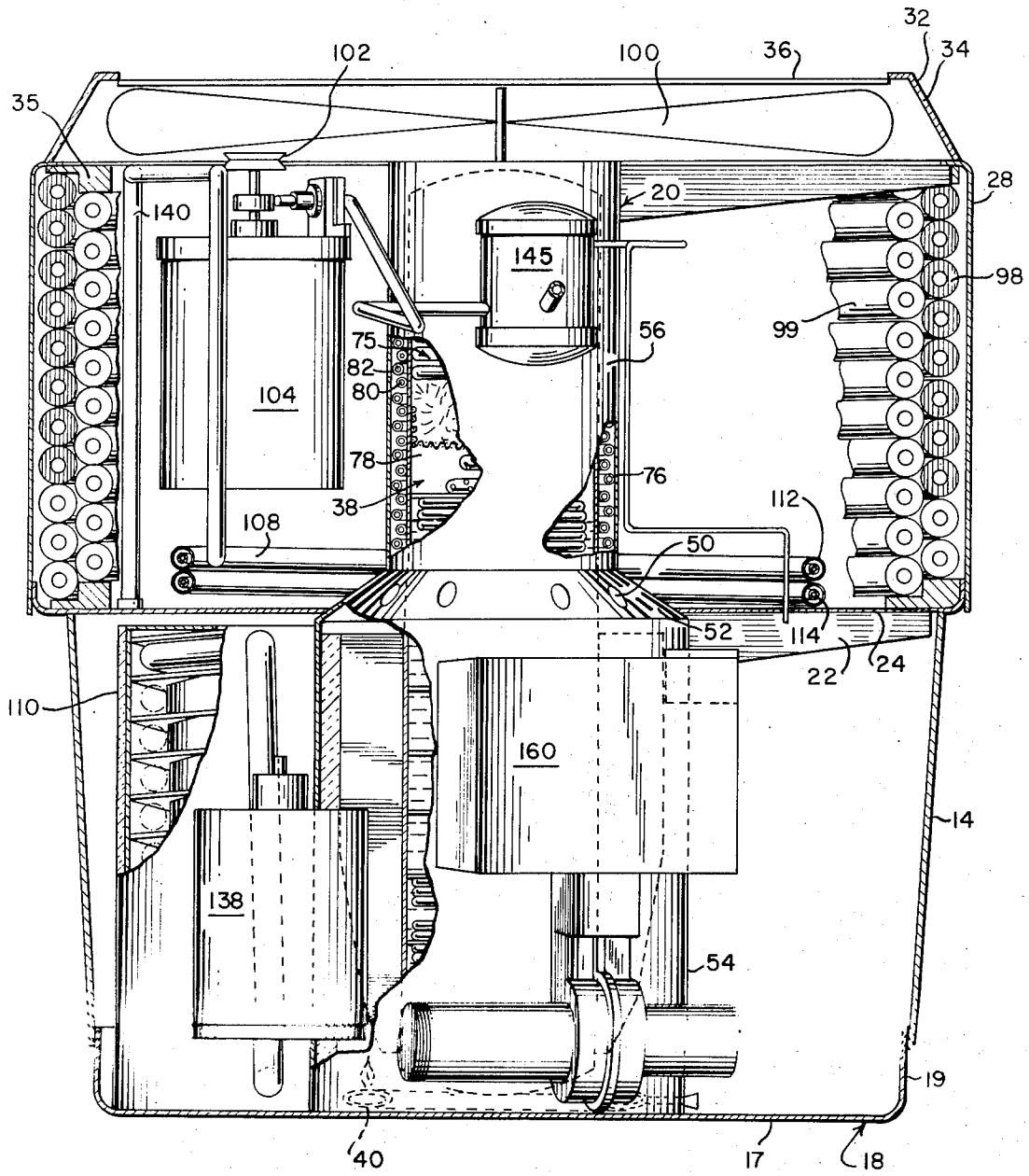
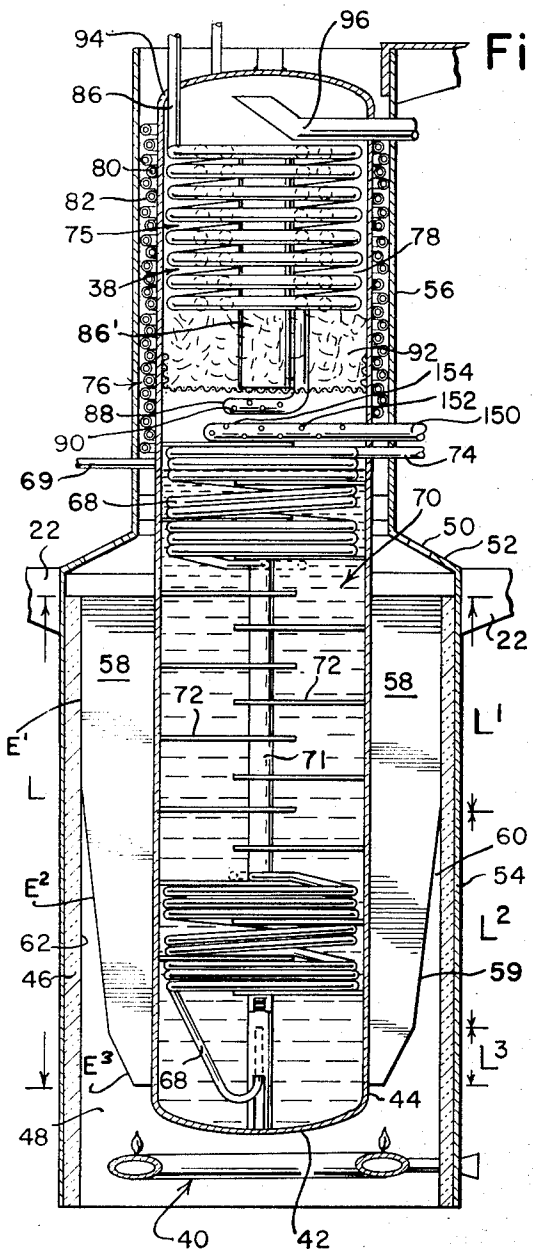

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Fig. 3

Fig. 4



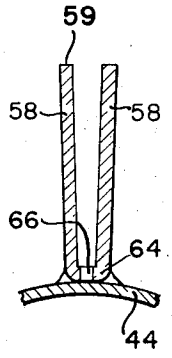




Fig. 5

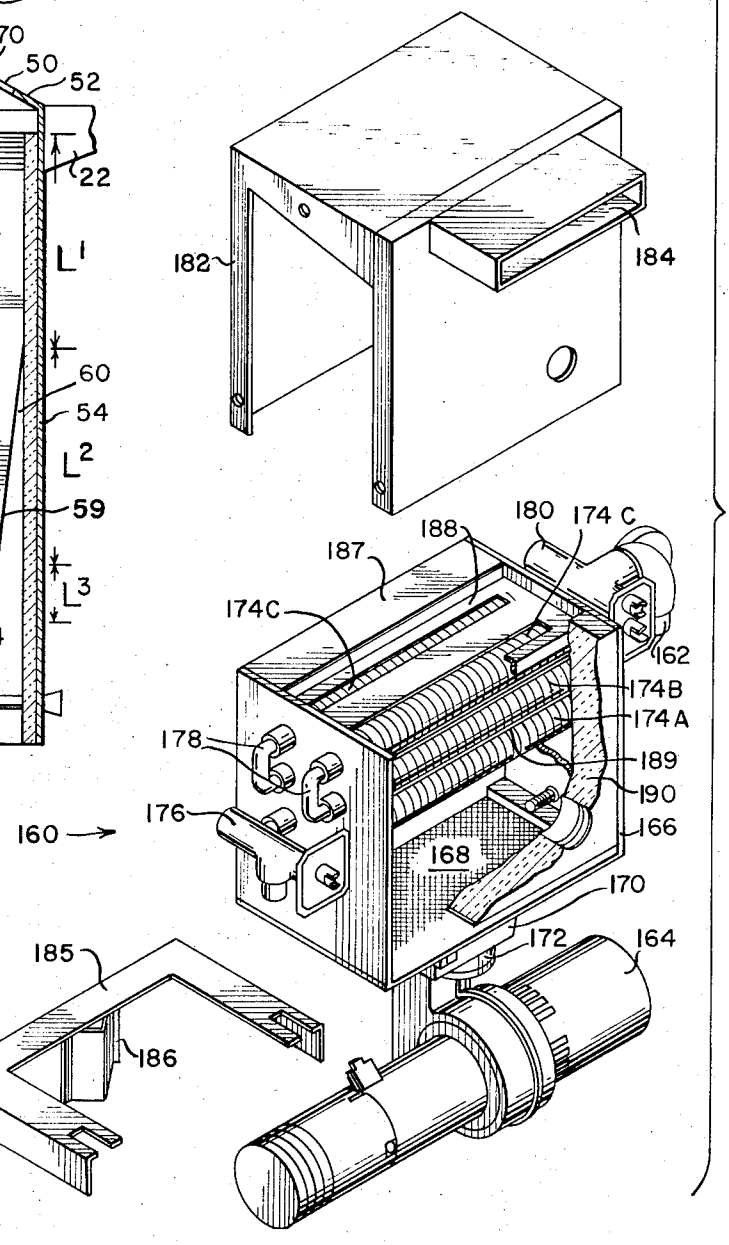



Fig. 7

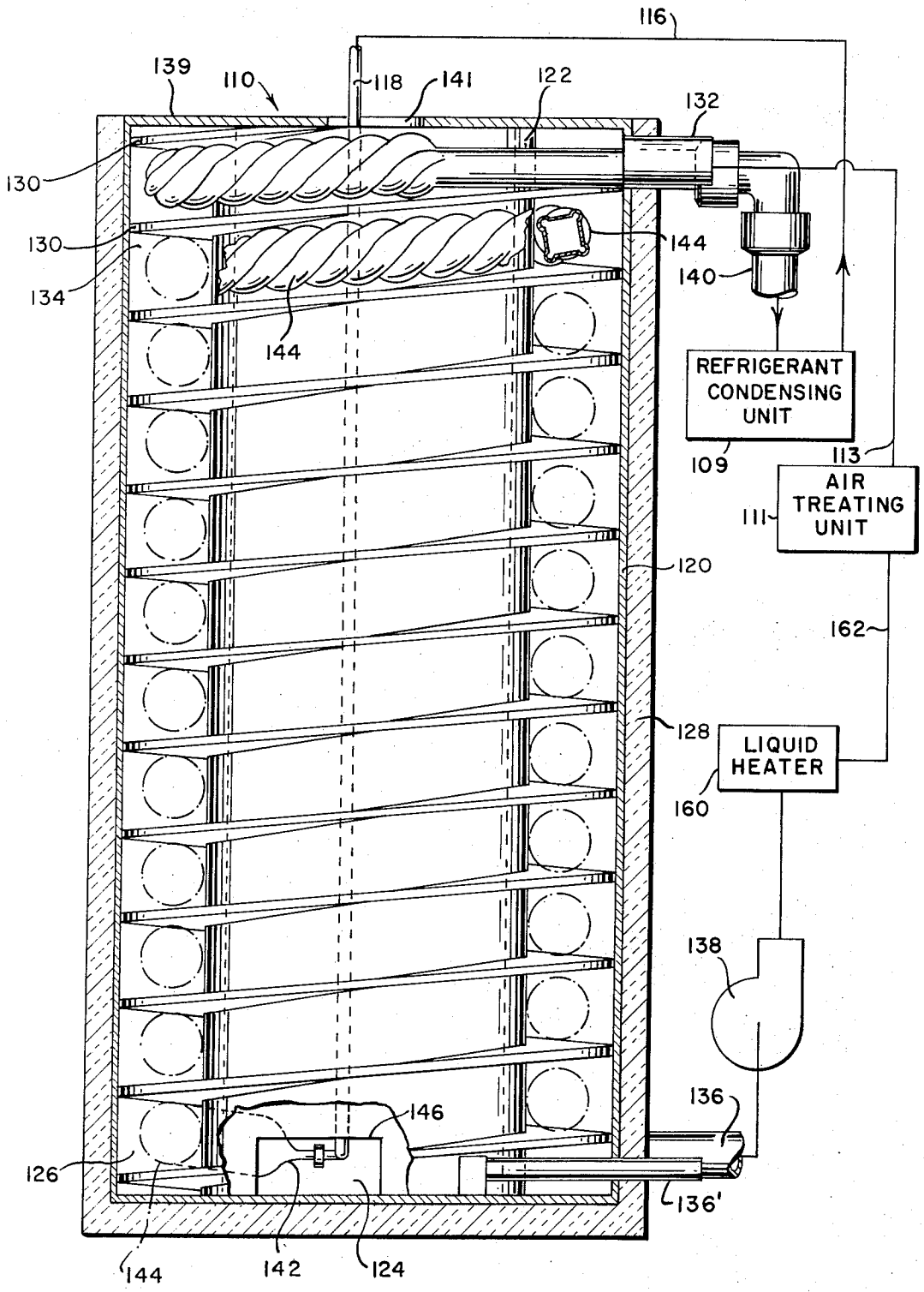

116
139
110
118
141
122
132
130
130
134
144
144
140
REFRIGERANT CONDENSING UNIT
109
113
AIR TREATING UNIT
111
120
162
128
LIQUID HEATER
160
138
136
146
126
136'
144
142
124

Fig.6

# COMPACT HEATING AND COOLING SYSTEM

The present invention relates to air conditioning systems and, in particular, to a compact air conditioning system which may be selectively operated for either cooling or heating the air conditioned space as desired.

There has recently been an increased demand for air conditioning heating and cooling units for use in residential space conditioning. In particular, the demand has increased for gas fired air conditioning units which are compact in size and quiet in operation while maintaining high standards of performance and reliability and with minimum service over extended periods of time.

In order to limit the amount of space occupied in a home or residential building by the air conditioning and heating systems, it has become desirable to produce residential gas air conditioning systems which can also serve as a heating system during the winter months and thus provide complete space conditioning for residences in a single unit or package. Another feature which is desired in air conditioning systems for homes is that the system be located out of doors, thereby to provide more occupiable space within the residence itself.

Accordingly, it is an object of the present invention to provide an economical, inexpensive and reliable air conditioning system for residential use.

Yet another object of the present invention is to provide space conditioning systems which satisfy the abovementioned demands and desires.

A further object of the present invention is to provide efficient and economical components for such systems.

In accordance with an aspect of the present invention, a compact air conditioning system is provided which includes a central, generally cylindrical hollow core on which substantially all of the components of the air conditioning system are mounted or supported. The core and the air conditioning components are enclosed within a removable frame structure which is not connected to any of the air conditioning components, so that the entire air conditioning system and its components can be conveniently exposed for assembly, inspection and repair. In one illustrative embodiment of the present invention, the space conditioning system is used to cool the interior of a building, e.g. a residential structure, and is located outside of the building, with only an air distribution plenum system, and a fan/coil heat exchanger unit located within the building. In another embodiment, the system can be readily converted to one which will selectively provide both cooling and heating.

In one preferred embodiment, the compact space conditioning system of the present invention includes a vapor generator assembly which is adapted to receive a strong refrigerant solution which is heated by a gas fired combustion means located below the generator to produce refrigerant vapor. A heat exchange condenser is connected in fluid communication with the generator for receiving and condensing the generated refrigerant vapor, with the cooled refrigerant liquid flowing from the condenser through a refrigerant heat exchanger. The latter is connected in fluid communication with a heat exchange evaporator, through a first restriction means, whereby cooled refrigerant liquid is supplied to



the evaporator for cooling a heat exchange medium flowing therein. The refrigerant heat exchanger receives refrigerant vapor from the evaporator and passes it countercurrently with the refrigerant liquid flowing from the condenser to the evaporator, thereby to further cool the refrigerant liquid prior to passage through the first restriction means to the evaporator. In addition, a heat exchange absorber is connected in fluid communication with the refrigerant heat exchanger and with a solution heat exchanger. Weak refrigerant solution is supplied from the generator through the solution heat exchanger to the absorber wherein the weak solution absorbs refrigerant vapor supplied from the evaporator. A second fluid flow restriction means is located between the solution heat exchanger and the absorber for maintaining a pressure differential therebetween. A solution pump is provided for pumping strong refrigerant solution produced in the absorber and supplying a first portion thereof directly to a rectifier heat exchanger, and a second portion thereof to the top of the analyzer via a solution heat exchanger, wherein the strong refrigerant solution flows in heat exchanger relation to the weak solution. Thus, heat is added to the second portion of the refrigerant solution prior to passage into the generator. In another embodiment of the invention, the air conditioning system is provided with a selectively operable boiler by which the system is conveniently converted from a cooling mode of operation to a heating mode.

The present invention provides an air conditioning system which is relatively compact in construction, since all of the components thereof are mounted on a single central core, in a close compact relationship to one another, so that the system can be conveniently installed out of doors adjacent the building to be conditioned and in as inconspicuous a location as possible. Accordingly, the air conditioning system does not occupy any valuable floor space within the building.

The above, and other objects, features and advantages of this invention, will be apparent in the following detailed description of an illustrative embodiment thereof which is to be read in connection with the accompanying drawings wherein:

FIG. **1** is a perspective view of a space conditioning unit constituting one embodiment of the present invention;

FIG. **2** is a diagrammatic view of the components of the space conditioning unit illustrated in FIG. **1**;

FIG. **3** is a sectional view, with parts broken away, taken along line **3—3** of FIG. **1**;

FIG. **4** is an enlarged vertical section of the vapor generator assembly utilized in the space conditioning unit of the present invention;

FIG. **5** is a plan view of a heat transfer fin utilized in the vapor generator assembly of FIG. **4**;

FIG. **6** is an enlarged sectional view of the evaporator of the unit of FIG. **1**; and

FIG. **7** is an exploded perspective view of the compact boiler of the unit of FIG. **1**.

Referring to FIGS. **1** and **2** of the drawings, it is seen that the space conditioning unit **10** of the present invention, which includes a gas fired absorption refrigeration system and a gas heating unit, is generally cylindrical with an outer casing or shell structure **12**. Casing **12** includes a lower wall **14** formed of panels of corrugated sheet metal secured to each other by a plurality of screws **16**. These panels are mounted upon a base **18**

formed by a circular bottom wall **17** and a peripheral flange **19** (FIG. **3**) for supporting the various components of the entire air conditioning unit.

The main structural component of the air conditioning unit is a central core **20** (FIG. **3**) which is centrally mounted on base **18** and provides an enclosure for the generator assembly and asociated components of the unit. Core **20** is formed by lower and upper cylinders **54** and **56** and a frustroconical collar **52** mounting cyliner **56** in vertical axial alignment on cylinder **54.** This core provides support for substantially all of the other components of the unit.

Each of a plurality of radially extending arms **22** is secured to core **20** and provides support for an intermediate annular support plate **24.** Corrugated panels **14** are secured between base **18** and arms **22** and provide a lower enclosure for various components of the unit. The upper portion of the unit is enclosed by a cylindrical, foraminous casing wall **28** which is formed of perforated sheet metal that defines a large number of relatively uniform openings **29** providing communication between the atmosphere and the interior of the unit, thereby permitting ambient air to flow into and through the upper portion of the unit. Casing wall **28** is supported on and secured to, support plate **24** in any convenient manner. The top of the unit is closed by a lid **34** resting upon a peripheral ring **35** secured to wall **28.** Lid **34** has an open wire top **36,** which permits ambient air to flow from the top of the unit.

As indicated above, unit **10** includes an absorption type refrigeration system which has a vapor generator assembly **38** enclosed within central core **20.** Generator assembly **38** is enclosed within a generally cylindrical pressure vessel to which a strong aqua-ammonia solution is supplied and in which refrigerant vapor is driven from the solution upon heating by a gas burner assembly **40.** Burner assembly **40** produces a flame front below the generator assembly **38** within the annular flue passages **48** of the generator assembly. The burner assembly is of the semi-powered blue flame type since combustion air is supplied to the venturi of the burner as a result of the slight vacuum created in the unit by the condenser fan **100,** more fully described hereinafter. This fan draws air in the unit and thus supplies air to the burner, which air is 100 percent premixed with the fuel gas so that no secondary air is required to complete the combustion process. This burner has an extremely short flame height; that reduces the overall height of the unit. Moreover, the air-to-fuel ratio is substantially stochiometric so that a peak flame temperature and a maximum efficiency are obtained.

The combustion products of burner assembly **40** are confined to an annular flue **48** adjacent the outer heat transfer surface **44** of generator assembly **38** up to the level of plate **24** by an insulation liner **46** on the inner surface of cylinder **54** of central core **20.** The products of combustion are discharged from flue **48** through apertures **50** in collar **52.**

The heat transfer from the products of combustion to the generator is provided by uniquely shaped heat transfer fins **58** (see FIGS. **4** and **5**) welded to the lower portion of the heat transfer surface **44.** The width of the fins **58** vary along their length **1,** which length in the preferred embodiment of the present invention is 13½ inches, so that each fin absorbs heat without damage at the same rate at which heat will pass through the fin and the heat exchange wall to the fluid contained therein when the temperature at the edge of the fin is near, but less than the maximum permissible temperature for the fin. By this arrangement, the fins do not have excessively hot spots along their surfaces and the life of the structure is prolonged.

The configuration of the outer edge of each of fins **58** will, in the optimum configuration, conform to a developed curve of predetermined characteristics. However, in the preferred embodiment of the invention, the edge configuration of the fins is formed by straight edge sections of predetermined slopes and the overall effect is an acceptable deviation from the optimum curve. Thus, as shown in FIG. **4,** fins **58** are constructed so that the lower portion thereof has a length $1^3$ (preferably 2.4 inches long) along which the fin extends from a minimum width (of 0.5 inches) to a first intermediate width (of 1.50 inches). Along this length of the heat exchanger fins, the combustion product gases are at relatively high temperatures and thus the dimensions of the fins must be small in order to prevent their becoming overheated by contact with those products of combustion. Along the length $1^2$ (preferably 4.5 inches long), fins **58** further expand their width to a maximum width (of 2 inches) at an intermediate point along their length. Along this portion of the lengths of the fin, the products of combustion are channeled between the fins toward surface **44** into the greater fin width, to transfer heat to the generator, without excessive heating of the fins. This is an important feature of the invention since the hotter gases adjacent liner **46** are gradually channeled or directed towards the inner portions of the fins to improve heat transfer without overheating the fins or creating hot spots such as would cause oxidation of the fins. Overheating and/or hot spots in the fins also is undesirable since it will cause breakdown of the refrigerant in the generator.

Finally, along a length $1^1$ (preferably 5.5 inches), the width of the fins is of a uniform dimension of 2 inches, and the edges **60** of the fins abut the surfaces **62** of the insulated liner **46** on the interior of cylinder **54.** Accordingly, it is seen that the distance between the edge **60** and the inside surface **62** of insulation **46** steadily decreases to an intermediate point along the lengths of the fins so that the flue gases progressively encounter the edges of the fin and are forced into the passageways formed between the fins. In this manner, as the combustion products between the fins cool and heat transfer drops, the higher temperature combustion products adjacent the outer ends of the fins are forced into and between the passages of the fins so as to maintain relatively uniform heat transfer with the generator, to improve and obtain a more efficient heat transfer between the combustion products and generator **38.**

In addition, since fins **58** extend parallel to each other, all of the heat exchanger surfaces are constantly swept by the combustion products, thereby improving heat transfer. Moreover, the construction of the generator, with the annular flue **48** in which fins **58** are located creates a slight pressure differential in the flue under the influence of condenser fan **100.** The pressure differential created by condenser fan **100** in this manner acts through the burner to draw ambient air through the venturi of the burner **40,** thereby providing 100 percent aeration for the burner to obtain maximum efficiency therewith.

In the preferred embodiment, fins **58** (see FIG. **5**) are in pairs, with each pair having a generally channel-shaped configuration with a bight portion **64** welded to the heat exchange wall **44** of generator **38.** The bight portion **64** has a series of spaced slots **66** along its length and the welding metal fills the slots. As a result, heat is transferred efficiently from the combustion products through fins **58** to the walls **44** and thence to the fluid in the generator. Alternatively, fins **58** may be formed as separate - independent plates welded or otherwise secured to the generator.

As mentioned above, a stream of strong aqua-ammonia solution is supplied to the generator assembly in order to produce refrigerant vapor and weak refrigerant solution. The refrigerant vapor produced in the generator moves upwardly towards the top of the generator assembly for use in the air conditioning system, as described hereinafter, while a weak solution at an acceptable level remains in the generator. This level generally extends to a position adjacent the top of an analyzer assembly **70** contained within the generator; and preferably to the level of a refrigerant check tube **69** extending from the generator wall **38.**

The weak solution flows from the generator, due to the pressure therein (as described more fully hereinafter) through a heat exchanger tube **68** of the analyzer assembly **70** contained within the generator. Tube **68** is a helix of a diameter so that it is spaced from the inner surface of vessel **38** and extends axially from the bottom of the generator assembly upwardly above the level of plate **24.** (It is noted that in FIG. **4** of the drawing, the central portion of the tube **68** has been broken away for clarity.)

Coaxial with tube **68** is the analyzer assembly **70,** formed by a central mounting post **71** supported on the bottom wall **42** of vessel **38.** This mounting post has a hollow lower end portion which receives the curved lower end **73** of tube **68.** By this construction the opened end **73** is directed away from the bottom of the generator and does not pick up, with the weak solution, any sediment lying on the generator bottom.

A series of mass transfer baffle plates **72** are mounted on post **71,** with each of the plates being slightly more than one-half of a disk having the radius of the inner surface of vessel **38.** The plates are mounted upon post **71** in alternated right and left relationship, as shown. Hence, one plate forms a baffle from one side of the vessel to beyond the post toward the opposite side, and each of the adjacent baffles form similar baffles from that opposite side beyond the post toward that one side. This construction forms a liquid-vapor counterflow relationship between the liquid flowing downwardly back-and-forth from plate to plate, and with vapor flowing upwardly.

Cool strong solution is supplied to the generator (as described hereinafter) and flows downwardly under the influence of gravity. This cooled solution passes over plates **72,** and over the windings of the heat exchanger tube **68,** so that it exchanges heat with the hot weak solution flowing in tube **68.** As a result, additional heat is supplied to the strong solution, thereby to produce vaporization of the refrigerant vapor therein, and the weak solution leaves the analyzer highly subcooled through an outlet **74** in tube **68.**

From outlet **74** the weak solution passes through an external solution heat exchanger **76** where further cooling of the weak solution takes place. The solution heat exchanger comprises a helically wound tube-within-a-tube assembly located concentrically around the upper portion **78** of vessel **38,** between the exterior wall of the vessel and the upper portion **56** of center core **20** (see FIG. **3**).

Solution heat exchanger **76** is used to transfer heat between the weak solution from the generator and a portion of the strong solution returning to the generator from the absorber. The weak solution flows through the inner tube **80** of the heat exchanger. This tube extends into and through a large diameter outer tube **82,** through which the strong solution flows with the weak solution and strong solution flowing countercurrently to each other in their respective tubes.

Solution heat exchanger **76** increases the thermal efficiency of the operating cycle of the air conditioning system, since heat must be supplied in the generator to the returning strong solution in order to vaporize the refrigerant and heat must be rejected from the weak solution in the absorber portion of the operating cycle. Thus, the exchange of heat between the streams of weak solution and returning strong solution reduces both the required heat input to the strong solution in the generator and the heat rejection from the weak solution in the absorber. As a result, a lower gas input rate is required in the burner **40** for boiling the ammonia vapor out of the refrigerant solution in the generator.

The weak solution, which is now highly subcooled by passage through solution heat exchanger **76,** passes from the heat exchanger through a restrictor **84,** i.e. a capillary tube, to the low pressure side of the system. After passing restrictor **84** the weak solution enters an absorber **99** wherein the weak solution absorbs refrigerant vapor prior to return to the generator.

The refrigerant vapor from generator **38,** which rises toward the top of the generator contains water vapor which must be removed from the refrigerant vapor. A portion of this water vapor is removed in the analyzer section of the generator wherein analyzer plates **72** function to provide maximum mass transfer contact between the countercurrent liquid and vapor streams so that the aqua-ammonia vapor directly contacts the cooler strong solution returning to the generator to cause condensation of some of the water vapor in the stream and vaporization of some of the ammonia in the strong solution droplets. Further purification takes place in the rectifier portion **75** of generator **38.** Rectifier **75** is located in vessel **38** directly above the analyzer section **70** and includes a tubular heat exchanger **86** which is helically wound around a closed hollow cylindrical core **86'**. A portion of the strong solution flows downwardly to the analyzer through tubular heat exchanger **86** and cools refrigerant gas vapor rising from the analyzer to cause further condensation of water vapor from the gas. The hollow cylindrical core **86'** within heat exchanger **86** serves to prevent the refrigerant gas vapor from flowing through the center of the heat exchanger and thus forces the vapor across the outer surfaces of the heat exchanger, to improve condensation. The water condensate from the refrigerant vapor stream drips downwardly on the outside of the rectifier heat exchanger **86** to the lower portion of the generator assembly thereby to form a portion of the weak solution.

In addition, the rectifier portion of the generator assembly includes a Raschig ring bed **92** at the lower sec-

tion of the rectifier heat exchanger **86** wherein the condensate formed in the rectifier on the surface of the heat exchanger **86** is refluxed prior to passage into the analyzer section of the generator.

The heat of condensation of the water vapor in the rectifier raises the temperature of the strong solution supplied through heat exchanger **86,** thereby further reducing the requirement for heat from burner **40.** The strong solution flows from the end **88** of heat exchanger **86** through a plurality of apertures **90** onto the top plate of the analyzer section of the generator. This strong solution combines with the other portion of the strong solution flowing from the solution heat exchanger and passes through analyzer **70,** exchanging heat and mass with the countercurrent vapor stream, and exchanging heat with the weak solution in the analyzer heat exchanger **68.**

The substantially pure ammonia refrigerant vapor at the top **94** of pressure vessel **38** leaves the vessel under pressure through conduit **96** and enters the condenser **98** wherein the vapor is cooled and condensed. It is noted that both the condenser **98** and absorber **99** are formed as finned, helically wound heat exchanger coils. These coils are located about the periphery of center core **20** and are positioned in adjacent and superimposed relationship to one another, as seen in FIGS. **2** and **3.** (For convenience, the fins of the condenser **98** have been shown in FIGS. **2** and **3** with cross-hatched shading, whereas those of the absorber **99** have been left clear.) The heat transfer coils of the absorber and condenser are supported on the central platform **24** which, in turn, is seated on and secured to the radially extending ribs **22** secured to core **20.** In this manner, the arrangement of the components of the conditioning system are made as compact as possible.

In this configuration, both the absorber and the condenser are exposed to ambient air flowing through exterior grid **28.** In order to draw this ambient air through grid **28,** a fan **100** is mounted at the top of central core **20,** and is driven through a belt and pulley arrangement **102,** as schematically illustrated in FIG. **3** of the drawing, from a motor-pump **104,** as more fully described hereinafter.

After an initial rapid drop in the temperature of the ammonia refrigerant vapor in the condenser, most of the refrigerant vapor is condensated in the condenser at essentially constant temperature (under the influence of air drawn thereover by fan **100**); with the liquid refrigerant leaving the condenser slightly subcooled. From the condenser **98** the liquid refrigerant is passed through a conduit **106** to a refrigerant heat exchanger **108** in which the liquid refrigerant exchanges heat with cooler-counterflowing two phase refrigerant mixture leaving the evaporator **110** of the air conditioning system.

Conduit **106** includes a cut restrictor **107** positioned therein between the condenser **98** and the refrigerant heat exchanger **108.** This restrictor serves to maintain the refrigerant in the condenser at an elevated temperature and pressure, thereby to obtain improved heat transfer in the condenser with the ambient air and reducing the amount of surface area which would be required for the condenser. Typically, the restrictor produces a 20 psi pressure drop between the condenser and heat exchanger **108.** In addition, the restrictor causes some flashing of the refrigerant as it passes therethrough so that a mixture of vapor and liquid flows into heat exchanger **108.** In the latter the refrigerant vapor is recondensed and thus further improves the heat exchange taking place therein.

Refrigerant heat exchanger **108** also constitutes a helically wound tube-within-a-tube heat exchanger (of the type described with respect to the solution heat exchanger) in which the liquid refrigerant from the condenser passes through a first or outer tube **112** and is cooled by the cooler refrigerant returning from evaporator **110** within an inner tube **114.** By thus further cooling the liquid refrigerant passing to the evaporator **110,** the thermal efficiency of the entire air conditioning system is further increased. The refrigerant heat exchanger also is supported on the intermediate support pan **24** (FIG. **3**) so as to provide as compact a configuration as possible.

The now highly subcooled liquid refrigerant is then passed through an outlet conduit **116** to an expansion valve or capillary tube **118,** wherein the subcooled liquid is throttled at constant enthalpy from the high pressure side (condenser) of the system to the low pressure side (evaporator) of the sysaem. Typically, the throttling process through the restrictor causes a small fraction, usually less than 10 percent of the liquid, to flash into a vapor within the restrictor itself, thereby further reducing the temperature of the refrigerant.

Evaporator **110** is the structure in which the heat exchange medium that is to be chilled by space conditioner **10** is passed. Typically, the heat exchange medium is supplied to the heat exchanger unit of an air/-coil system in which ambient air is blown over a heat exchanger coil within the home, cooled (or heated) thereby, and supplied through a plenum or duct work system throughout the various rooms of the house. In the preferred embodiment of the invention the heat exchange medium used in the evaporator **110** is an ethylene glycol solution, which will not freeze during the winter months.

As illustrated in FIG. **6** of the drawing, evaporator **110** comprises an outer cylindrical vessel **120** which has a vertical axis and contains an inner cylindrical sump tank **122.** Tank **122** has an aperture **124** at its bottom which provides communication with an annular space **126** formed between the tank and vessel **120.** The latter is covered by an insulation layer **128,** and is mounted on base **18** adjacent core **20,** below the condenser and absorber. A spiral vane or baffle **130** is secured to the periphery of tank **122** and has a width equal to the width of the annular space **126** so that the baffle forms a closed spiral heat exchange conduit or passage **134.**

Heat exchange medium returning from the air coil unit in the house is supplied through an inlet port **132** to the uppermost portion of the spiral conduit **134.** As a result, the heat exchange medium is forced to flow downwardly along the spiral path of conduit **134** to the base of evaporator **110** wherein it is discharged through a conduit **136** for supply to the air/coil unit. Conduit **136** is connected in any convenient manner to a suitable pump **138,** which causes the heat exchange medium to flow to and from the air/coil unit in the house.

Evaporator **110** has a top opening **139** through which capillary tube **118** extends downwardly through the center of tank **122.** The liquid refrigerant from the refrigerant heat exchanger **112** passes through capillary tube **118,** and the interior of core **122,** to the inlet end

portion **142** of the evaporator heat exchanger tube **144.** This tube, in the preferred embodiment of the present invention, comprises a one inch diameter aluminum fluted tube which is spirally wound and extends through the spiral conduit **134** to the upper portion of the heat exchanger so that the cold two phase refrigerant mixture passing from capillary tube **118** passes countercurrently through the evaporator, with the heat exchange medium, thereby to chill the heat exchange medium during the air conditioning mode of operation of the device. In order to provide improved air conditioning operation, fluted tube **144** has a generally square cross-section, as seen most clearly in FIG. **6,** and is twisted about its longitudinal axis so as to form a spiral configuration throughout its entire length. This spiral configuration improves the contact of the heat exchange medium with the surface of the tube **144** as the heat exchange medium flows through conduit **134,** thereby to enhance the heat transfer between the cold two phase refrigerant mixture within the tube and the heat exchange medium flowing over the exterior in conduit **134.**

It is noted that capillary tube **118** passes through the aperture **124** formed in the lower portion of core **122** for connection to the end **142** of tube **144.** As mentioned, this aperture serves to provide liquid communication between the interior of the tank **122** and annular space **126** (and thus conduit **134**), whereby the center of tank **122** acts as a reservoir for extra chilled heat exchange medium. Moreover, as described hereinafter, during the heating mode of operation of the conditioning system of the present invention, this chamber (i.e. the interior of tank **122**) acts as an expansion chamber for the heat exchange medium.

An additional conduit **136'** is connected to evaporator **110** and extends therethrough into interior tank **122.** The right end of this tube is connected, outside of the evaporator, to a plastic tube or the like (not shown) by which the liquid level in the tank **122** can be checked. That is, by holding the plastic tube vertically, the tank **122,** conduit **137** and the plastic tube act as a manometer. Of course, the plastic tube may be provided with a pinch valve or the like to prevent discharge of fluid from tank **122.**

From evaporator **110,** the two phase refrigerant mixture passes through conduit **140** to the inlet side of tube **114** in refrigerant heat exchanger **108,** wherein it serves to cool refrigerant flowing in tube **112** from condenser **98.** From tube **114,** the two phase refrigerant mixture flows through a conduit **142** to absorber **99.** As the two phase refrigerant mixture enters absorber **99,** it is mixed with the weak solution flowing through capillary tube **84** from generator **38** and solution heat exchanger **76.** As a result, the weak solution absorbs refrigerant vapor in the two phase refrigerant mixture. The heat released by the absorption process taking place in absorber **99** is discharged or rejected from the absorber by the ambient air which is drawn over the absorber by fan **100,** and thus is rejected into the atmosphere.

From absorber **99,** the now strong solution refrigerant liquid is passed through a purge pot or reservoir **145** to pump **104.** The latter is mounted on the outer surface of the upper portion **56** of center core **20** and is constructed in accordance with the hermetically sealed pump shown and described in U.S. Patent application Ser. No. 313,756, filed Dec. 11, 1972, the disclosure of which is incorporated herein by reference. Pump **104** draws solution from absorber **99,** increases its pressure and discharges the strong liquid refrigerant solution along two lines **87** and **148.**

Conduit **87** supplies a first portion of the strong solution directly to the rectifier heat exchanger in the upper portion of the generator, wherein the solution is heated by the condensation of water vapor on the outer portion of tube **86** and by the passage of refrigerant vapor upwardly to the top of the generator. Line **148,** on the other hand, supplies a second portion of the strong solution to the outer tube **80** of solution heat exchanger **76,** wherein it passes in countercurrent heat exchange relation with weak solution flowing from generator **38,** through conduit **74,** thereby to further increase the temperature of the strong solution and decrease the temperature of the weak solution passing to the absorber. The strong solution passes from the solution heat exchanger through conduit **150,** wherein the solution is supplied through a plurality of apertures **152** in the free end **154** of conduit **150** directly above the uppermost analyzer plate **72** of analyzer **70.**

Accordingly, the refrigeration cycle is completed. As thus described, the space conditioning system of the present invention is adapted to be used as a highly efficient air conditioning system for cooling the interior of a home or the like. In one preferred embodiment of the present invention the system is constructed to produce 36,000 BTU's per hour of cooling capacity. The cooling system operating in this mode has proved to be highly satisfactory, efficient, quiet and to have an extended useful life, over and above that of the previously proposed systems. Moreover, because of the compact construction of the air conditioning system, with substantially all of the components mounted on or otherwise supported by the central core member **20** in a predetermined planned configuration, a compact assembly is provided in which each of the components is independent of the exterior framework of the system. Thus, the components are readily accessible for repair and the exterior shell of the system can be conveniently removed without damage or movement of the interior parts. Still further, the system is substantially smaller than previously proposed absorption air conditioning systems and thus would be unobtrusive when located outside of the home.

In one embodiment of the present invention the above-identified space conditioning system is adapted to be used as a heating system during the winter months. In this embodiment of the invention the system is provided with a compact water boiler **160,** located downstream of the heat exchange medium pump **138.** This boiler is located within the shell **10** of the space conditioning system and is mounted on center core **20,** or otherwise secured to or supported in the lower pan **18** of the system.

In the heating mode of operation of the invention, burner **40** is not in operation and the air conditioning components are inactive. Thus, the heat exchange medium flowing between the evaporator **110** and the air/coil unit in the residence, simply flows into evaporator **110** through inlet **132,** through spiral conduit **134,** and is discharged through the conduit **136** to pump **138.** The latter supplies the heat exchange medium to boiler **160,** wherein the heat exchange medium is heated to the desired temperature and supplied through conduit **162** to the air/coil unit within the house.

On the other hand, in the air conditioning mode of operation, the heat exchange medium will also flow through boiler **160,** as illustrated in FIG. **2** of the drawing. However, the boiler will be inoperative (i.e. shut off) but heat exchange medium will flow through the heat transfer coil within the boiler. By the novel and unique construction of boiler **160** the temperature of the chilled heat exchange medium flowing through the boiler is not substantially effected as it passes therethrough.

Boiler **160** is more clearly illustrated in FIG. **7** of the drawing; as seen therein, the boiler includes a powered air blower **164** for pressurizing ambient air and supplying the same with gas to the burner **166.** The combustion blower **164** mixes the gas supplied from a gas supply line (not shown) with the required amount of air and forces the mixture through a frame holder screen **168.** The flame holder preferably is formed of a **20** mesh Inconel wire screen located above a plenum chamber **170** in which there is located an antiflashback wire screen, adjacent the outlet **172** of the combustion blower. Preferably, flame holder **168** has a size of six inches by three inches, and is located directly below a series of copper finned heat transfer tubes **174.**

Heat transfer tubes **174** are arranged in a stacked configuration, with the lowermost tubes **174***a* in fluid communication with a header **176** to which the heat exchange medium is supplied from pump **138.** The heat exchange medium flows through the lowermost tubes **174***a*, thence through a manifold (not shown), upwardly to the heat exchange tubes **174***b* and across the flame holder **168** in an opposite direction; thence through U tubes **178** to the uppermost tubes **174***c;* and thence through an outlet discharger head **180** to the conduit **162.**

In a preferred embodiment of the invention, the fins on the lowermost pair of tubes **174***a* have an external diameter which is less than the diameter of the fins on tubes **174***b*. The fins on the latter tubes, in turn, have a smaller diameter than the fins on the tubes **174***c*. This is done because the products of combustion encounter tubes **174***a* before tubes **174***b* and in turn before tubes **174***c*. Since the temperature of the products of combustion is higher when they encounter tubes **174***a*, the smaller fins are used to transfer less heat to the tubes and the heat exchange medium contained therein, thereby preventing damage to the fins on the lowermost tube, while also preventing any thermal degradation by overheating of the heat exchange medium flowing within the tubes.

Preferably boiler **160** is provided with slotted baffle plates **188, 189** between the pairs of tubes **174,** as illustrated in FIG. **7** of the drawing. These baffles serve to divert the products of combustion around the entire periphery of each of the heat transfer tubes to provide better contact therebetween and thus better efficiency in transfer of heat from the products of combustion to the heat exchange medium passing through the tubes.

The burner portion **166** of boiler **160** is covered by a shroud **182,** of sheet metal construction, having combustion products exhaust **184** which completely encloses the burner portion of the boiler so as to insure efficient contact of the combustion products with heat exchanger tubes **174.** Preferably the boiler construction is mounted on a frame **185** which is in turn secured by welding or the like through a bracket **186** to the center core **20** of the space conditioning system. It is also noted that the exterior walls **187** of the boiler are preferably insulated with a high temperature insulating material **190** to insure that substantially all of the heat of the products of combustion is transferred to the heat exchange medium and is not lost through the walls of the boiler. Finally, it is noted that because of the relatively small area of the flame holder and combustion blower outlet **172,** through which the heat exchange tubes **174** are exposed to atmospheric conditions during the air conditioning cycle of operation of the present invention, there is a minimum cooling loss by natural convection through the boiler during the air conditioning cycle.

Pump **138,** used to circulate heat exchange medium from the air conditioning system **10** of the air coil unit located within the house or residence, can be provided in two different embodiments. In one embodiment pump **138** may simply be a centrifugal pump driven by a belt takeoff arrangement (not shown) from the drive shaft of the motor **104.** The driven centrifugal pump is used when the system is built to function only as an air conditioner, since in that mode of operation the heat exchange medium is pumped to the house only when motor **104** is operating. (In this form of the invention boiler **160** also is eliminated.) On the other hand, where the system is to be used both as a heating and a cooling system, then pump **138** is provided as a separately powered electric pump since it must operate when boiler **160** is operating to heat the heat exchange medium. Of course, in the heating mode of operation motor **104** is not operating.

Of course, it is to be understood that various ignition and safety controls may be provided in the apparatus of the present invention, as may be thermostatic temperature control arrangements. However, the manner of providing such ignition and thermostatic controls is a matter of choice, as they can be selected in any of a variety of manners, as would occur to those skilled in the art. Accordingly, such controls are not described herein in detail. In addition, it is noted that although unit **10** and the various components thereof are shown in detail, the fluid connections between the components are not shown in complete detail as those connections would be apparent to one skilled in the art, particularly in view of the schematic representation thereof in FIG. **2.**

Accordingly, it is seen that a relatively simple system is provided for selectively operating the space conditioning system of the present invention as an air conditioner or as a heating system. This enables the evaporator to be placed in series with the boiler and water pump, without the loss of cooling capacity in the air conditioning mode of operation of the device. This is an important feature in cost savings in constructing a system which can provide both heating and cooling, since it makes use of the same components in both the heating and cooling cycles. These components include the indoor heat exchanger coil, heat exchanger medium piping, water pump, ignition system, gas pressure regulator and chiller tank evaporator tank which, as mentioned above, provides an expansion tank within its inner core **122,** during the heating mode of operation, for the heat exchange medium.

It will also be appreciated that the present invention provides a relatively simple and inexpensive air conditioning and/or heating system in a single space condi-

tioner which is of a compact construction utilizing a minimum number of components. Moreover, the space conditioner of the present invention is gas powered so that it has flexibility in providing both heating and cooling in a single compact arrangement, utilizing relatively inexpensive natural gas. Finally, the space conditioning system of the present invention is highly efficient in operation.

Although an illustrative embodiment has been described herein with reference to the accompanying drawings, it is to be understood that the invention is not limited to that precise embodiment and that various changes and modifications may be effected therein by one skilled in the art without departing from the scope or spirit of this invention.

What is claimed is:

**1.** In an air conditioning system, the combination of a central, generally cylindrical hollow core, a vertical cylindrical refrigerant vapor generator assembly adapted to receive liquid to be vaporized and being contained within said cylindrical core, gas fuel combustion means disposed within said core beneath said generator for heating liquid therein, a helically wound tubular condenser supported on and surrounding said central core connected in fluid communication with said generator to receive refrigerant vapor therefrom, fan means mounted on said central core above said generator and condenser for producing ambient air flow for cooling refrigerant vapor flowing in said condenser, a tubular refrigerant heat exchanger supported on and surrounding said central core and connected in fluid communication with said condenser for receiving liquid therefrom, an evaporator, and first restriction means providing fluid communication between said refrigerant heat exchanger and said evaporator, whereby cooled refrigerant liquid is supplied to said evaporator for cooling a heat exchange medium flowing therein, said refrigerant heat exchanger receiving vapor from said evaporator countercurrently from liquid flowing therethrough from said condenser, thereby to cool said liquid from said condenser prior to passage thereof through said restriction means; a helically wound tubular absorber supported on and surrounding said central core adjacent said condenser and operatively connected to said refrigerant heat exchanger to receive refrigerant vapor from said evaporator, said refrigerant vapor flowing in said absorber being cooled by ambient air flow produced by said fan means, a helically wound tubular solution heat exchanger supported on and surrounding said central core and connected in fluid communication between said generator and said absorber for supplying weak refrigerant solution to said absorber for absorbing said refrigerant vapor therein, second fluid flow restriction means located between said solution heat exchanger and said absorber, and solution pump means for pumping refrigerant solution from said absorber and supplying a first portion thereof directly to the upper portion of said generator and a second portion thereof to said solution heat exchanger wherein strong refrigerant solution flows in heat exchange relation to said weak solution, whereby heat is added to said second portion of the strong refrigerant solution prior to passage into said generator.

**2.** An air conditioning system as defined in claim **1** which includes an analyzer column contained within said generator assembly and comprising a helically wound tubular weak solution conduit having an open lower end located adjacent the base of said generator for receiving weak solution therefrom and an upper end in fluid communication with said solution heat exchanger for supplying weak solution thereto; and a plurality of mass transfer plates mounted in said generator between windings of said weak solution conduit for removing and purifying refrigerant vapor from said strong solution while weak solution flowing through said conduit is cooled by said strong solution.

**3.** An air conditioning system as defined in claim **2** which includes a rectifier mounted above said analyzer comprising a tubular conduit and a hollow cylindrical core, said tubular conduit being helically wound about said core and having one end thereof connected in fluid communication to said pump means and an opposite end open to the interior of said generator to supply strong solution from said pump to said analyzer, whereby srong solution flowing therein is heated, and refrigerant vapor flowing upwardly in said generator is cooled by contact with said conduit to condense water vapor in said refrigerant vapor, thereby to purify said refrigerant vapor.

**4.** An air conditioning system as defined in claim **3** wherein said solution heat exchanger is constructed as a cylindrically wound tube within a tube whereby said weak solution flows countercurrently in one of said tubes with respect to said portion of the strong solution flowing in the other of said tubes.

**5.** An air conditioning system as defined in claim **1** wherein said evaporator comprises a generally cylindrical shell having a central hollow cylindrical core contained within said shell to define an annular fluid flow chamber therebetween, said evaporator core having an aperture therein providing fluid communication between the interior thereof and said annular fluid flow chamber, a helically wound vane secured to said evaporator core and extending between said core and said shell, thereby to define a spiral conduit in said shell for said heat exchange medium flowing therein; and a helically wound tubular heat exchanger concentric with said central generator core and extending through said fluid flow chamber, said last mentioned heat exchanger being connected in fluid communication to said first restriction means and said refrigerant heat exchanger, thereby to cool said heat exchange medium flowing in said fluid flow conduit.

**6.** The air conditioning system as defined in claim **5** wherein said evaporator heat exchanger comprises a fluted tube having a generally square cross-sectional configuration and being helically wound along its longitudinal axis, said refrigerant and said heat exchange medium flowing countercurrently in said fluted tube and said spiral conduit respectively, for efficient heat exchange therebetween.

**7.** The air conditioning system as defined in claim **6** wherein said first restriction means comprises a capillary tube extending through said evaporator central core and connected through said core to said fluted heat exchanger adjacent the base of said core, said core providing a reservoir chamber for heat exchange medium flowing in said fluid flow conduit.

**8.** The air conditioning system as defined in claim **1** wherein said vapor generator assembly comprises a vessel for fluid to which heat is to be transferred and having a heat transfer wall with an outer surface located in spaced relation to the interior surface of said central cylindrical hollow core thereby to define a flue

therebetween for products of combustion flowing upwardly from said combustion means, and a plurality of heat exchange fins located in said flue and being operatively connected to said vessel in intimate heat transfer relationship therewith, said heat transfer fins extending longitudinally in the flow direction of said products of combustion to define flow passages for said products of combustion between adjacent fins and having a width dimension which tapers along a predetermined pattern from a minimum dimension adjacent the base of said vessel to a maximum dimension adjacent the top of said vessel, which maximum dimension is equal to the width of said flue, whereby the space between the edges of said fins and the interior wall of said core decreases in the flow direction of said products of combustion and said products of combustion encounter said edges and flow through said passageways to transfer heat to said fins and said vessel, said predetermined width pattern for said fins being selected in accordance with the temperature of said products of combustion to allow heat to pass into the fins from said products of combustion at the optimum rate at which heat passes through said fins without damage to the fins.

**9.** The air conditioning system as defined in claim **8** wherein said fins are formed in pairs, with each of said pairs of fins comprising a generally U-shaped member in section having a bight portion welded to said heat transfer wall of said vessel.

**10.** An air conditioning system comprising a generally vertically extending refrigerant vapor generator adapted to receive strong refrigerant solution, gas fired combustion means below said generator for heating strong solution contained therein, a heat exchange condenser connected in fluid communication with said generator for receiving and cooling refrigerant vapor from said generator, a refrigerant heat exchanger connected in fluid communication with said condenser for receiving cooled refrigerant liquid therefrom, a heat exchange evaporator, and first restriction means providing fluid communication between said refrigerant heat exchanger and said evaporator whereby cooled refrigerant liquid is supplied to said evaporator for cooling a heat exchange medium flowing therein, said refrigerant heat exchanger being adapted to receive refrigerant vapor from said evaporator and pass it countercurrently with refrigerant liquid from said condenser prior to passage through said first restriction means, a heat exchange absorber connected to said refrigerant heat exchanger in fluid communication for receiving and cooling refrigerant vapor therefrom, a solution heat exchanger connected in fluid communication with said generator and said absorber for supplying weak refrigerant solution from said generator to said absorber for absorbing refrigerant vapor therein; second fluid flow restriction means between said solution heat exchanger and said absorber for maintaining a pressure differential therebetween, and a solution pump means for pumping strong refrigerant solution from said absorber and supplying a first portion thereof directly to the upper portion of said generator and a second portion thereof to said solution heat exchanger, wherein said strong refrigerant solution flows in heat exchanger relation to said weak solution whereby heat is added to said second portion of the strong refrigerant solution prior to passage into said generator.

**11.** The air conditioning system as defined in claim **10** wherein said generator includes an analyzer column contained therein comprising a helically wound tubular weak solution conduit having an open lower end located adjacent the base of said generator for receiving weak solution therefrom and an upper end in fluid communication with said solution heat exchanger for supplying weak solution thereto; and a plurality of mass transfer plates mounted in said generator between windings of said weak solution conduit to remove and purify refrigerant vapor from said strong solution while weak solution flowing through said conduit is cooled by said strong solution.

**12.** The air conditioning system as defined in claim **11** wherein said generator further includes a rectifier mounted therein above said analyzer, said rectifier comprising a tubular conduit and a hollow cylindrical core, said tubular conduit being helically wound about said core and having one end thereof connected in fluid communication to said pump means and an opposite end to open to the interior of said generator to supply strong solution from said pump to said analyzer, whereby strong solution flowing therein is heated, and refrigerant vapor flowing upwardly in said generator is cooled by contact with said conduit to condense water vapor in said refrigerant vapor, thereby to purify said refrigerant vapor.

**13.** The air conditioning system as defined in claim **12** wherein said first restrictor means comprises a capillary tube extending through said evaporator central core and connected through said core to said fluted heat exchanger adjacent the base of said core, said core providing a reservoir chamber for heat exchange medium flowing in said fluid flow conduit.

**14.** The air conditioning system as defined in claim **10** wherein said evaporator comprises a generally cylindrical shell having a central hollow cylindrical core contained within said shell to define an annular fluid flow chamber therebetween, said evaporator core having an aperture therein providing fluid communication between the interior thereof and said annular fluid flow chamber, a helically wound vane secured to said evaporator core and extending between said core and said shell, thereby to define a helical conduit in said shell for said heat exchange medium flowing therein; and a helically wound tubular heat exchanger concentric with said central evaporator core and extending through said fluid flow chamber, said last mentioned heat exchanger being connected in fluid communication to said first restriction means and said refrigerant heat exchanger, thereby to cool said heat exchange medium flowing in said fluid flow conduit.

**15.** The air conditioning system as defined in claim **14** wherein said evaporator heat exchanger comprises a fluted tube having a generally square cross-sectional configuration and being helically wound along its longitudinal axis, said refrigerant vapor and said heat exchange medium flowing countercurrently in said fluted tube and said spiral conduit respectively for efficient heat exchange therebetween.

**16.** The air conditioning system as defined in claim **10** wherein said vapor generator comprises a pressure vessel for refrigerant solution to which heat is to be transferred and having a heat transfer wall with an outer surface, confining wall means surrounding said vessel and having a wall portion spaced from said outer surface, thereby to define a flue therebetween for products of combustion flowing upwardly from said gas fired combustion means, and a plurality of heat ex-

change fins located in said flue and being operatively connected to said vessel in intimate heat transfer relationship therewith, said heat transfer fins extending longitudinally in the flow direction of said products of combustion to define flow passages for said products of combustion between adjacent fins and having a width dimension extending between said pressure vessel said confining wall which tapers along a predetermined pattern from a minimum dimension adjacent the base of said vessel to a maximum dimension adjacent the top of said vessel, which maximum dimension is equal to the width of said flue, whereby the space between the edges of said fins and said confining means wall portion decreases in the flow direction of said products of combustion, whereby said products of combustion encounter said edges and flow through said passageways to transfer heat to said fins and said vessel, said predetermined width pattern for said fins being selected in accordance with the temperature of said products of combustion to allow heat to pass into the fins from said products of combustion at the optimum rate at which heat passes through said fins without damage to the fins.

**17.** The air conditioning system as defined in claim **10** wherein said fins are formed in pairs, with each of said pairs of fins comprising a generally U-shaped member in section having a bight portion welded to said heat transfer wall of said vessel.

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# UNITED STATES PATENT OFFICE

# CERTIFICATE OF CORRECTION

Patent No. 3,828,575 Dated August 13, 1974

Inventor(s) Norman D. Malcosky; Ronald H. McLean; Kanwal N. Singh; Chung M. Auh

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the heading directly below United States Patent "Mallosky et al." is changed to --Malcosky et al.--.

Signed and sealed this 19th day of November 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

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